

## CLAIMS

What is claimed is:

- 1    1.     A method for collecting and processing data in a sensor network,  
2     comprising:
  - 3       coupling a plurality of network elements including at least one node  
4       among an environment and at least one client computer;
  - 5       collecting data from the environment;
  - 6       remotely controlling at least one function of the at least one node;
  - 7       providing node information including node resource costs and message  
8       priority from the at least one node to the plurality of network elements; and
  - 9       distributing processing of the collected data among the plurality of  
10      network elements in response to the node information.
- 1    2.     The method of claim 1, wherein the at least one node includes sensing,  
2     processing, communications, and storage devices supporting a plurality of  
3     processing and protocol layers.
- 1    3.     The method of claim 1, further comprising supporting at least one  
2     communication mode selected from a group consisting of wireless  
3     communications, wired communications, and hybrid wired and wireless  
4     communications.
- 1    4.     The method of claim 1, further comprising coupling the at least one  
2     node to the at least one client computer through the plurality of network  
3     elements, wherein the plurality of network elements includes at least one  
4     gateway, at least one server, and at least one network.
- 1    5.     The method of claim 4, further comprising performing at least one  
2     function using the at least one gateway, wherein the at least one function is  
3     selected from a group consisting of protocol translation, sensor network  
4     management, management of transmissions from a remote user, and interfacing

5       with at least one communication physical layer including wired local area  
6       networks, packet radio, microwave, optical, wireline telephony, cellular  
7       telephony, and satellite telephony.

1       6.       The method of claim 4, wherein the at least one network comprises  
2       wired networks, wireless networks, and hybrid wired and wireless networks,  
3       wherein the at least one network comprises at least one network selected from a  
4       group comprising the Internet, local area networks, wide area networks,  
5       metropolitan area networks, and information service stations.

1       7.       The method of claim 1, further comprising internetworking among the  
2       plurality of network elements to provide remote accessibility using World Wide  
3       Web-based tools for data, code, management, and security functions, wherein  
4       data includes signals or images, wherein code includes signal processing,  
5       decision support, and database elements, and wherein management includes  
6       operation of the at least one node and the sensor network.

1       8.       The method of claim 4, wherein the plurality of network elements  
2       further includes at least one device selected from a group consisting of repeaters  
3       and interrogators.

1       9.       The method of claim 1, further comprising coupling at least one local  
2       user to the at least one node.

1       10.      The method of claim 1, further comprising establishing at least one  
2       redundant information pathway among the plurality of network elements.

1       11.      The method of claim 1, wherein the plurality of network elements  
2       comprise a plurality of network element sets, wherein the plurality of network  
3       element sets are layered.

1       12.      The method of claim 1, wherein the at least one node comprises a  
2       plurality of node types, wherein the plurality of node types includes at least one  
3       node of a first type and at least one node of a second type, wherein a first

4 network having a first node density is assembled using the at least one node of a  
5 first type, wherein a second network having a second node density is assembled  
6 using the at least one node of a second type, wherein the second network is  
7 overlayed onto the first network.

1 13. The method of claim 1, further comprising predistributing code and data  
2 anticipated for future use through the sensor network using low priority  
3 messages, wherein the code and the data are downloadable from at least one  
4 location selected from a group consisting of storage devices of the plurality of  
5 network elements, and storage devices outside the sensor network.

1 14. The method of claim 1, further comprising automatically organizing the  
2 plurality of network elements in response to the node information, wherein the  
3 organizing comprises automatically controlling data transfer, processing, and  
4 storage within the sensor network.

1 15. The method of claim 1, further comprising supporting a plurality of  
2 levels of synchronization among different subsets of the plurality of network  
3 elements, wherein a first level of synchronization is supported among a first  
4 subset of the plurality of network elements, wherein a second level of  
5 synchronization is supported among a second subset of the plurality of network  
6 elements.

1 16. The method of claim 1, further comprising controlling data processing  
2 using at least one processing hierarchy, the at least one processing hierarchy  
3 controlling at least one event selected from a group consisting of data  
4 classifications, data transfers, data queuing, data combining, processing  
5 locations, communications among the plurality of network elements.

1 17. The method of claim 1, further comprising transferring data using  
2 message packets, wherein the message packets are aggregated into compact  
3 forms in the at least one node using message aggregation protocols, wherein the  
4 message aggregation protocols are adaptive to at least one feature selected from

5 a group consisting of data type, node density, message priority, and available  
6 energy.

1 18. The method of claim 17, wherein the message packets include decoy  
2 message packets, wherein information to be transferred is impressed on random  
3 message packets to provide communication privacy.

1 19. The method of claim 1, wherein the at least one function includes data  
2 acquisition, data processing, communication, data routing, data security,  
3 programming, and node operation.

1 20. The method of claim 1, further comprising coupling at least one  
2 preprocessor to at least one processor and a plurality of application  
3 programming interfaces (APIs) in the at least one node, wherein the plurality of  
4 APIs are coupled to control at least one device selected from a group consisting  
5 of sensors, actuators, communications devices, signal processors, information  
6 storage devices, node controllers, and power supply devices, wherein the  
7 plurality of APIs support remote reprogramming and control of the at least one  
8 device.

1 21. The method of claim 20, wherein the plurality of APIs are layered.

1 22. The method of claim 20, further comprising enabling distributed  
2 resource management with the plurality of APIs by providing network resource  
3 information and message priority information to the plurality of network  
4 elements.

1 23. The method of claim 22, wherein information transfer among the  
2 plurality of network elements is controlled using a synchronism hierarchy  
3 established in response to the resource information and message priority  
4 information.

1 24. The method of claim 20, wherein the at least one preprocessor performs  
2 at least one function selected from a group consisting of data acquisition, alert

3       functions, and controlling at least one operating state of the at least one node,  
4       wherein the at least one processor performs at least one function selected from a  
5       group consisting of signal identification, database management, adaptation,  
6       reconfiguration, and security.

1       25.      The method of claim 1, further comprising controlling data processing  
2       and transmission in the at least one node in response to a decision probability of  
3       a detected event.

1       26.      The method of claim 1, further comprising coupling the at least one  
2       node to at least one sensor selected from a group consisting of seismic, acoustic,  
3       infrared, thermal, force, vibration, pressure, humidity, current, voltage,  
4       magnetic, biological, chemical, acceleration, and visible light sensors.

1       27.      The method of claim 26, further comprising:  
2                 processing data gathered by the at least one sensor;  
3                 generating a predetermined identifying code representing the processed  
4       data; and

5                 propagating the identifying code through the sensor network, wherein a  
6       high priority message containing information regarding a high priority event is  
7       represented by a high priority message code, and wherein receipt of the high  
8       priority message code by the at least one node invokes a priority protocol that  
9       causes message packets to be broadcast to nodes adjacent to a path that will  
10      inhibit messaging from nodes not engaged in conveying the information  
11      regarding the high priority event.

1       28.      The method of claim 1, further comprising self-assembling the plurality  
2       of network elements, wherein search and acquisition modes of the at least one  
3       node search for participating ones of the plurality of network elements, wherein  
4       a determination is made whether each of the participating ones of the plurality  
5       of network elements are permitted to join the sensor network using a message  
6       hierarchy, wherein the sensor network is surveyed at random intervals for new  
7       nodes and missing nodes.

1       29.     The method of claim 1, further comprising self-assembling the plurality  
2     of network elements into a multi-cluster network.

1       30.     The method of claim 29, wherein a start node is selected as a base node,  
2     wherein the base node communicates an assembly packet throughout the sensor  
3     network, wherein information of the assembly packet alternates with each  
4     successive communication between directing a node to become a base node of a  
5     particular cluster number and directing a node to become a remote node of a  
6     particular cluster number, wherein the particular cluster number is incrementally  
7     changed with each successive communication of the assembly packet.

1       31.     The method of claim 29, wherein at least one start node is selected as at  
2     least one base node, wherein the at least one base node communicates an  
3     assembly packet throughout the sensor network, wherein information of the  
4     assembly packet alternates with each successive communication between  
5     directing at least one node to become at least one base node of a particular  
6     cluster number and directing at least one other node to become at least one  
7     remote node of a particular cluster number, wherein the particular cluster  
8     number is incrementally changed with each successive communication of the  
9     assembly packet.

1       32.     The method of claim 29, further comprising establishing synchronism  
2     among the plurality of network elements using the assembly packets.

1       33.     The method of claim 1, further comprising managing the sensor network  
2     as a distributed and active database using a distributed resource management  
3     protocol, wherein the plurality of network elements are reused among different  
4     applications, wherein the network elements are used in multiple classes of  
5     applications.

1       34.     The method of claim 1, wherein the plurality of network elements  
2     further comprises at least one database including at least one storage device

3 selected from a group consisting of storage devices coupled to at least one of the  
4 plurality of network elements and storage devices of the at least one node.

1 35. The method of claim 34, wherein the at least one database comprises  
2 data-driven alerting methods that recognize conditions on user-defined data  
3 relationships including coincidence in signal arrival, node power status, and  
4 network communication status.

1 36. The method of claim 34, further comprising implementing the at least  
2 one database in small foot print databases at a level of the at least one node and  
3 in standard query language (SQL) database systems at a level of at least one  
4 server.

1 37. The method of claim 1, further comprising:  
2 collecting data by the at least one node;  
3 performing at least one operation on the collected data in response to  
4 parameters established by a user, the at least one operation selected from a  
5 group consisting of energy detection, routing, processing, storing, and fusing.

1 38. The method of claim 37, wherein the routing, processing, storing, and  
2 fusing are performed in response to at least one result of the energy detection.

1 39. The method of claim 37, wherein the routing comprises selecting at least  
2 one data type for routing, selecting at least one of the plurality of network  
3 elements to which to route the selected data, selecting at least one route to the  
4 selected at least one of the plurality of network elements, and routing the  
5 selected at least one data type to the selected at least one of the plurality of  
6 network elements.

1 40. The method of claim 37, wherein the processing comprises selecting at  
2 least one data type for processing, selecting at least one processing type,  
3 selecting at least one of the plurality of network elements to perform the  
4 selected at least one processing type, and transferring the selected at least one

5 data type to the selected at least one of the plurality of network elements using  
6 at least one route through the sensor network.

1 41. The method of claim 40, wherein selecting at least one processing type  
2 comprises determining at least one probability associated with a detected event  
3 and selecting at least one processing type in response to the at least one  
4 probability.

1 42. The method of claim 40, further comprising aggregating data processed  
2 in a plurality of nodes for further processing by other nodes.

1 43. The method of claim 40, further comprising aggregating data processed  
2 by the at least one node for reporting to at least one user.

1 44. The method of claim 37, wherein the storing comprises selecting at least  
2 one data type for storage, selecting at least one storage type, selecting at least  
3 one of the plurality of network elements to perform the selected at least one  
4 storage type, and transferring the selected at least one data type to the selected  
5 at least one of the plurality of network elements using at least one route through  
6 the sensor network.

1 45. The method of claim 37, wherein the fusing comprises transmitting at  
2 least one query request from a first node to at least one other node, wherein the  
3 first node collects data from the at least one other node in response to the at  
4 least one query request and processes the collected data.

1 46. The method of claim 1, wherein the at least one node comprises a  
2 plurality of nodes with each of the plurality of nodes including at least one bi-  
3 static sensor and a generator for producing at least one energy beam that is  
4 radiated from the plurality of nodes, wherein the at least one energy beam  
5 comprises a combined probe beam and signal code for beam intensity control  
6 and propagation measurement, wherein the at least one energy beam is  
7 modulated in time to provide an identifying code corresponding to a source

- 8 node, wherein the at least one energy beam is a type selected from a group  
9 comprising infrared, visible, acoustic, and microwave beams.
- 1 47. The method of claim 1, further comprising determining a position of the  
2 at least one node.
- 1 48. The method of claim 1, further comprising transferring software among  
2 the plurality of network elements, wherein the software transfer is remotely  
3 controllable.
- 1 49. The method of claim 1, further comprising protecting communications  
2 using at least one public key security protocol.
- 1 50. The method of claim 1, further comprising providing location and time  
2 information to the plurality of network elements using a Global Positioning  
3 System (GPS) device.
- 1 51. The method of claim 1, further comprising communicating among the  
2 plurality of network elements using at least one communication modem.
- 1 52. The method of claim 1, further comprising communicating among the  
2 plurality of network elements using multihop communications.
- 1 53. The method of claim 1, wherein the environment is at least one  
2 environment selected from a group consisting of electronic equipment,  
3 mechanical equipment, electro-mechanical equipment, a facility, a structure, a  
4 material, a transportation system, a vehicle, an outdoor area, an indoor area, a  
5 biological system, a person, and an animal.
- 1 54. The method of claim 1, further comprising:  
2 providing a plurality of software modules;  
3 supporting couplings among the plurality of software modules using a  
4 plurality of interfaces;  
5 reusing the plurality of interfaces among the plurality of software  
6 modules by changing at least one inter-module coupling; and

7           dynamically configuring the plurality of software modules at run-time.

1       55.    A method for providing a sensor network, comprising:  
2           coupling a plurality of network elements including at least one node  
3           among at least one environment and at least one client computer using at least  
4           one coupling with the Internet;  
5           remotely controlling functions of the plurality of network elements;  
6           providing node information including node resource cost and message  
7           priority to the plurality of network elements in response to at least one  
8           parameter of at least one signal received from the at least one environment; and  
9           controlling at least one function of the plurality of network elements in  
10          response to the node information.

1       56.    The method of claim 55, wherein the at least one parameter is remotely  
2          programmed using the at least one client computer.

1       57.    The method of claim 55, wherein the at least one function includes at  
2          least one function selected from a group consisting of programming,  
3          configuring, assembling the plurality of network elements, distributing  
4          processing among the plurality of network elements, establishing  
5          communication paths among the plurality of network elements, selecting at least  
6          one mode of communication among the plurality of network elements,  
7          distributing data among the plurality of network elements, storing data,  
8          organizing at least one subnetwork among the plurality of network elements,  
9          controlling synchronization among the plurality of network elements,  
10         assembling data products, and reporting.

1       58.    A method of operating a sensor network, comprising:  
2           coupling a plurality of network elements including at least one node  
3           among an environment and at least one client computer with at least one  
4           Internet coupling;  
5           collecting data from the environment; and

6           remotely programming and controlling at least one function of the at  
7   least one node via internetworking among the plurality of network elements.

1   59.    The method of claim 58, further comprising:  
2        providing node information including node resource information and  
3        message priority to the plurality of network elements;  
4        distributing processing of the collected data to the plurality of network  
5        elements in response to the node information.

1   60.    A computer readable medium containing executable instructions which,  
2   when executed in a processing system, cause the processing system to collect  
3   and process data in a sensor network by:

4        coupling a plurality of network elements including at least one node  
5        among an environment and at least one client computer;  
6        collecting data from the environment;  
7        remotely controlling at least one function of the at least one node;  
8        providing node information including node resource costs and message  
9        priority from the at least one node to the plurality of network elements; and  
10      distributing processing of the collected data among the plurality of  
11     network elements in response to the node information.

1   61.    An electromagnetic medium containing executable instructions which,  
2   when executed in a processing system, cause the processing system to collect  
3   and process data in a sensor network by:

4        coupling a plurality of network elements including at least one node  
5        among an environment and at least one client computer;  
6        collecting data from the environment;  
7        remotely controlling at least one function of the at least one node;  
8        providing node information including node resource costs and message  
9        priority from the at least one node to the plurality of network elements; and  
10      distributing processing of the collected data among the plurality of  
11     network elements in response to the node information.

1       62.     A computer readable medium containing executable instructions which,  
2     when executed in a processing system, cause the processing system to provide a  
3     sensor network by:

4                 coupling a plurality of network elements including at least one node  
5     among at least one environment and at least one client computer using at least  
6     one coupling with the Internet;

7                 remotely controlling functions of the plurality of network elements;  
8                 providing node information including node resource cost and message  
9     priority to the plurality of network elements in response to at least one  
10    parameter of at least one signal received from the at least one environment; and  
11                 controlling at least one function of the plurality of network elements in  
12     response to the node information.

1       63.     An electromagnetic medium containing executable instructions which,  
2     when executed in a processing system, cause the processing system to provide a  
3     sensor network by:

4                 coupling a plurality of network elements including at least one node  
5     among at least one environment and at least one client computer using at least  
6     one coupling with the Internet;

7                 remotely controlling functions of the plurality of network elements;  
8                 providing node information including node resource cost and message  
9     priority to the plurality of network elements in response to at least one  
10    parameter of at least one signal received from the at least one environment; and  
11                 controlling at least one function of the plurality of network elements in  
12     response to the node information.